

AD-A112 511 CENTER FOR NAVAL ANALYSES ALEXANDRIA VA NAVAL STUDIE--ETC F/6 21/4
MOBILITY FUELS FOR THE NAVY.(U)
JAN 82 T O'NEILL
UNCLASSIFIED CNA-PP-336 N00014-76-C-0001
NL

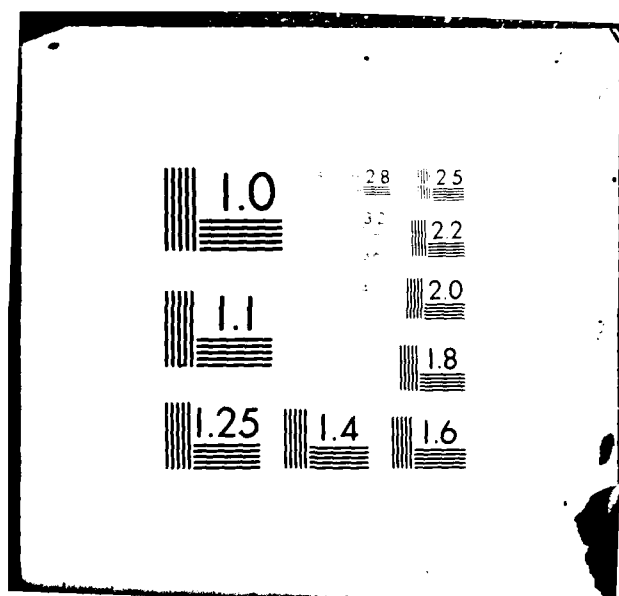
[of]

AD-A

12-11

12-11

END
DATE
FILMED
04-82
DTIC



2

PROFESSIONAL PAPER 336 / January 1982

111111

MOBILITY FUELS FOR THE NAVY

Thomas O'Neill

For use in the
development of the
document



CENTER FOR NAVAL ANALYSES

DTIC
ELECTRIC
MAR 26 1982
A

PROFESSIONAL PAPER 336 / January 1982

MOBILITY FUELS FOR THE NAVY

Thomas O'Neill

AD NUMBER	DATE Jan 82	DTIC ACCESSION NOTICE
1. REPORT IDENTIFYING INFORMATION		
A. ORIGINATING AGENCY Center for Naval Analyses		REQUESTER: 1. Put your mailing address on reverse of form. 2. Complete items 1 and 2. 3. Attach form to reports mailed to DTIC. 4. Use unclassified information only.
B. REPORT TITLE AND OR NUMBER PP 336, Mobility Fuels for the Navy		
C. MONITOR REPORT NUMBER		
D. PREPARED UNDER CONTRACT NUMBER N00014-76-0001		
2. DISTRIBUTION STATEMENT Cleared for Public Release		DTIC: 1. Assign AD Number. 2. Return to requester.

DTIC FORM 50
DEC 80

PREVIOUS EDITIONS ARE OBSOLETE

CENTER FOR NAVAL ANALYSES

PROFESSIONAL PAPER 336 / January 1982

MOBILITY FUELS FOR THE NAVY

Thomas O'Neill

Naval Inst. E. 0001

Accepted for publication in Naval Institute Proceedings.



Naval Studies Group

CENTER FOR NAVAL ANALYSES

2000 North Beauregard Street, Alexandria, Virginia 22311

AC
NA
✓
Little m. file

A

MOBILITY FUELS FOR THE NAVY

THE OUTLOOK FOR MOBILITY FUELS

A decade ago the Navy experienced few problems with the cost and quality of the fuel its ships and aircraft used. Oil was cheap and high-quality distillate fuel was readily available and could be allowed to replace lower quality ship fuels.

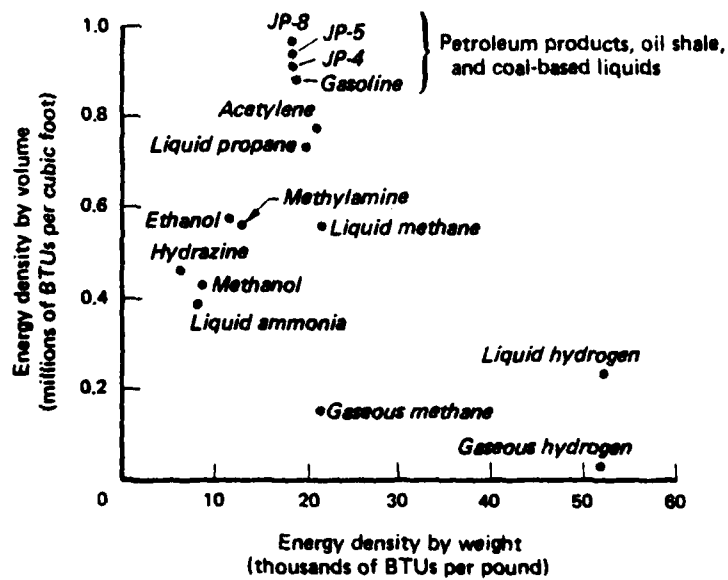
During the 1970s, the situation changed dramatically. Crude oil prices shot up, thereby increasing the relative importance of fuel in operating and support costs. For example, the percentage of direct operating and support costs attributable to fuel rose over the period 1973 to 1980 from about 5 to 33 percent for representative ships and from about 10 to 38 percent for typical aircraft. Also, lower quality crudes became more prevalent on the world market as the search for oil began to include heavier crude oil from new sources, such as Alaska, and from older fields, through use of enhanced recovery techniques. This lead to lower fuel quality. Quality here is used to mean the characteristics of a fuel relative to well-refined petroleum products that determine how it burns. The trend toward higher prices and lower quality will continue in the future.

Another major change in Navy fuels will occur with the introduction of synthetics produced from shale, tar sands, and coal over the next few decades. Synfuels will most likely be mixed with petroleum-derived products, so that the chemistry of future fuels will be more complex than it is today. This will have a profound effect on the engines that burn these fuels.

An even more radical change would result from the widespread use of other energy sources. Hydrogen and alcohol are two substances mentioned frequently. Although it would certainly be desirable to supplement dwindling petroleum reserves with other sources of energy, a number of problems would first have to be solved before alternative fuels could be employed on a large scale. Some of these are mentioned in the following section.

ALTERNATIVE MOBILITY FUELS

Many substances have been suggested as candidate fuels to replace oil. Some of the more likely candidates are arranged in figure 1 according to two important properties: energy density by weight and by volume. For ships and aircraft, the amount of energy that can be released from a given volume of fuel is a more relevant parameter than the energy density by weight. This is because these vehicles are primarily volume limited, which means that their drag (and consequently their fuel consumption) is related more to their volume than their weight.



Source: [1]

FIGURE 1: ENERGY DENSITY, PER MASS AND PER VOLUME, OF VARIOUS CANDIDATE FUELS

Hydrogen exhibits by far the greatest energy content by weight of any fuel, because it is so light. Although this characteristic makes it an excellent rocket propellant, that does not imply that it should be the choice for ships or aircraft. Even in liquefied form, its energy density by volume is so low that a hydrogen-fueled vehicle would require a fuel tank four times the size of the tank in a comparable petroleum-fueled vehicle to achieve the same range. Alternatively, the range of the hydrogen burner would be limited to one-quarter the range of the latter.

As figure 1 shows, petroleum-derived fuels and the synthetics have greater energy content per volume than the alternatives. Another advantage of petroleum and close substitutes lies in their greater availability. It is true that both hydrogen and alcohol have potentially abundant resources bases. Hydrogen gas can be released from seawater, and ethyl alcohol (ethanol) can be fermented from grain. However, processes used to produce fuels from these sources are quite energy intensive and are not economically viable at present. Other substances generally are even less readily available, at least in usable form.

There are two more problems that argue against the extensive use of fuels radically different from oil. First, many candidate fuels are difficult to store and handle. Some compounds are very toxic, corrosive, reactive, or explosive, while others, such as liquid hydrogen and liquid methane (essentially liquefied natural gas), are cryogenic

and therefore require special precautions and excessive insulation. Second, widespread use of exotic fuels would require adapting or replacing engines and supporting infrastructure that have been designed for oil.

A recent study of alternative fuels for the maritime industry by the National Academy of Sciences [2] concluded that synfuels, which essentially mimic petroleum, are the only alternatives that are expected to be burned in commercial ships and aircraft powered by gas turbines through the year 2000. The study also predicted that some types of diesels and steam powerplants could potentially employ solid coal or coal-oil slurries. However, because of the advantages of petroleum and synfuels, they will remain the mainstay of both civilian and military fuels through at least the next few decades. Other energy sources are possibilities for a more distant future, when the proper infrastructure has been built up and engines have been adapted.

LOWER FUEL QUALITY

Although the primary Navy fuels during the next few decades will be produced from oil or synthetic substitutes, they will not be identical to today's distillates. The quality of the crude oil on the world market has already begun to deteriorate, due to a change from predominantly sweet (low-sulphur), light crudes to a greater percentage of *sour* (high-sulphur), heavy crude oil. These lower quality sources require more extensive processing to yield high-quality distillate fuels for ships and aircraft (DFM and JP-5, respectively).

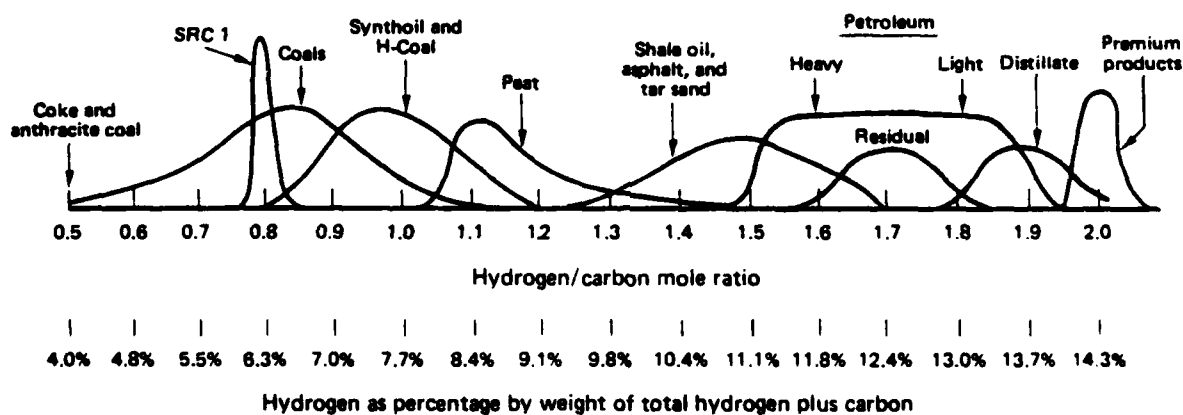
Synthetic crudes obtained from shale oil, tar sands, and coal must be processed even more than residual or heavy oil. This requirement is illustrated in figure 2 by the extent to which the hydrogen-to-carbon mole ratios of these hydrocarbon sources have to be upgraded to provide distillate-grade fuel. Either extensive hydrogenation (hydrogen addition) or pyrolysis (carbon removal) steps would have to be performed, especially to use coal. These completely different processing techniques would, in turn, require substantial technological and economic investments.

Many feedstocks also contain high levels of containments, such as sulphur, ash, nitrogen, and heavy metals. The quantities of these contaminants should be greatly reduced in additional processing operations, because some can poison refinery catalysts, while others cause pollution or contribute to engine corrosion. Although additives are frequently employed to help counteract these and other problems, additives themselves can produce undesirable side effects.

In theory future energy sources could be processed sufficiently to produce high-quality distillates, but in practice this will not be accomplished, due to prohibitive costs. Since the Defense Department accounts for only about 2.5 percent of total U.S. oil consumption, it cannot exert enough influence on the oil market to force producers to provide high-quality fuel at lower prices for the military. In fact, many refineries that now supply military fuels are small and cannot perform the hydrotreating or hydrocracking steps necessary to upgrade

Note:

SRC 1, Synthoil, and H-Coal are names of representative hydrogenation processes that convert coal to a higher grade of solid or to liquids or gases.



Source: [3]

FIGURE 2: HYDROGEN CONTENT OF VARIOUS HYDROCARBON FUEL SOURCES AND PRODUCTS

low-quality sources. Thus, in the future, virtually all fuels will be higher priced but still be lower in quality than they are now.

EFFECTS ON ENGINES

As fuel quality declines, problems with engine maintenance and reliability will increase. Some of the factors that bring this about are discussed briefly here. Many fuels have a prevalence of long-chain hydrocarbons. These chemicals raise fuel viscosity and cause restricted fluid movement and perhaps clogging within fuel filters or small engine passages. Furthermore, these heavy hydrocarbons, along with aromatics and other ring structures, increase corrosion or erosion rates in diesels and gas turbines, because they do not burn completely. When they are present in significant quantities, smoking can occur as well. Contaminants remaining in the fuel after processing can also speed up the rate of corrosion or erosion.

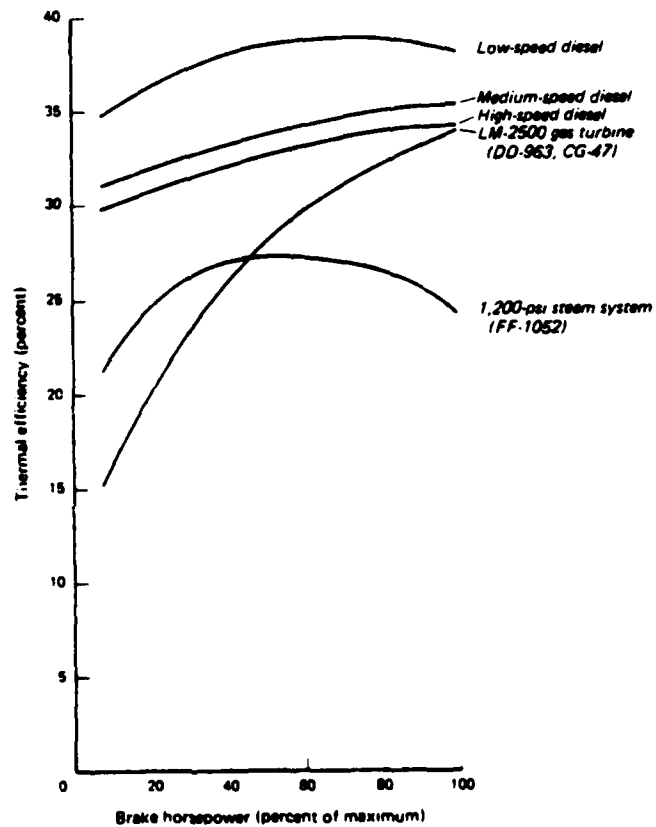
The engines most susceptible to these problems are aircraft gas turbines, because their components are very complex and built to fine tolerances. A study by Pratt and Whitney Aircraft [4], for example, has concluded that commercial gas turbines would probably be severely affected by high aromatics levels in distillate fuels. The study also anticipated that the use of a specific low-quality fuel would increase smoke and emission levels and drastically shorten the life of certain engine components--by about 40 percent for combustor liners and up to 60 percent for turbine airfoils. High levels of sulphur and heavy-metal contaminants would probably result in additional damage.

Most other engine types are less sensitive than gas turbine engines to fuel quality variations. Marine medium- and high-speed diesels can be designed to be somewhat more tolerant of low-quality fuel. Low-speed diesels are substantially more resistant, primarily because their larger combustion zone allows for more complete burning. However, this greater size, in conjunction with increased weight and noise, is disadvantageous, especially for warships. Steam powerplants, in particular those ordered since the mid-1960s, are the least sensitive of all marine engines to low-quality fuels. In fact, existing steam plants could probably be adapted to burn coal-oil slurries, while future ones may even be designed for pulverized or stoker coal.

An additional advantage of diesels and steam plants over gas turbines is their greater fuel efficiency during cruise operations (15 to 20 percent of full load). This is illustrated in figure 3. Diesels are more efficient even at high-power settings.

CHANGES TO FUELS

Interrelationships between the price and quality of fuel have already been noted. Fuel availability is another factor in this equation. The quality demanded by Navy specifications for any fuel type has quite an effect on the amount of that fuel the refiner can produce from a given crude. Exxon has estimated that JP-5 production could be boosted about 40 percent by increasing the freeze point 10°F above the present value of -51°F [6]. Similarly, a 10°F reduction in the flash point from 140°F would allow about a 25-percent increase in yield. Of



Source: [5]

FIGURE 3: THERMAL EFFICIENCIES OF PROPULSION SYSTEMS

course, other considerations, particularly safety, impinge on decisions to change fuel specifications.

As fuel quality declines, both specifications and engine designs will have to be modified to accommodate this change. In addition, specifications have to reflect the fact that fuel chemistry itself is undergoing change, so that new problems have begun to arise. Recently, batches of DFM and JP-5 that passed inspection have been associated with fuel filter clogging and excessive smoking. The mechanisms of these effects are not clearly understood. As synfuels are introduced, the variety of chemicals in fuels will be greatly expanded, and this will cause a new range of problems.

Besides modifying the specifications of current fuels to address the issues of price and availability, other ways might come from changing the types of fuel burned. The Navy could attempt to switch to fuels in civilian use. Number 2 diesel oil is similar to the ship fuel DFM, while Jet A-1 is not unlike the aircraft fuel JP-5. Another approach could involve the use of just one type of fuel for both ships and airplanes. This would reduce storage and handling costs, perhaps enough to offset the modest differential of 5 cents per gallon between JP-5 and DFM that existed in October 1981.

These are just a few of the means to deal with changes in fuels. As fuel quality degrades, the Navy will have to expand its current efforts in this area. A far-reaching research and development effort and prudent planning will hedge against uncertainties in the quality, quantity, and price of future fuels.

REFERENCES

- [1] Naval War College, Center for Advanced Research, "Production of Marine and Aviation Fuel by Factory Ships at Sea," by Maj. J. F. Bald and Maj. J. P. Kuspa, Jun 1980
- [2] National Academy of Sciences, Maritime Transportation Research Board, "Alternative Fuels for Maritime Use," May 1980
- [3] Whitehurst, D. D., "A Primer on Chemistry and Constitution of Coal," American Chemical Society, Symposium 71: Organic Chemistry of Coal, 1-35, 1978
- [4] Lohmann, R. P., et al., "The Impact of Broad Specification Fuels on High Bypass Turbofan Engine Combustors," NASA CR-159454, Pratt and Whitney Aircraft Commercial Products Division, Dec 1978
- [5] Naval Sea Systems Command (SEA 313), C. Kenyon, private communication, 7 Oct 1981
- [6] Exxon Research and Engineering Co., "Effects of Refining Variables on the Properties and Composition of JP-5," by M. Lieberman and W. F. Taylor, Nov 1980

CMA PROFESSIONAL PAPERS - 1978 TO PRESENT*

- PP 211
Mizrahi, Maurice M., "On Approximating the Circular Coverage Function," 14 pp., Feb 1978, AD A054 429
- PP 212
Mangel, Marc, "On Singular Characteristic Initial Value Problems with Unique Solution," 20 pp., Jun 1978, AD A058 535
- PP 213
Mangel, Marc, "Fluctuations in Systems with Multiple Steady States. Application to Lancaster Equations," 12 pp., Feb 78 (Presented at the First Annual Workshop on the Information Linkage Between Applied Mathematics and Industry, Naval PG School, Feb 23-25, 1978), AD A071 472
- PP 214
Weinland, Robert G., "A Somewhat Different View of The Optimal Naval Posture," 37 pp., Jun 1978 (Presented at the 1976 Convention of the American Political Science Association (APSA/IUS Panel on "Changing Strategic Requirements and Military Posture"), Chicago, Ill., September 2, 1976), AD A056 228
- PP 215
Colle, Russell C., "Comments on: Principles of Information Retrieval by Manfred Kochen," 10 pp., Mar 78 (Published as a Letter to the Editor, Journal of Documentation, Vol. 31, No. 4, pages 298-301), December 1975), AD A054 426
- PP 216
Colle, Russell C., "Lotka's Frequency Distribution of Scientific Productivity," 18 pp., Feb 1978 (Published in the Journal of the American Society for Information Science, Vol. 28, No. 6, pp. 366-370, November 1977), AD A054 425
- PP 217
Colle, Russell C., "Bibliometric Studies of Scientific Productivity," 17 pp., Mar 78 (Presented at the Annual meeting of the American Society for Information Science held in San Francisco, California, October 1976), AD A054 442
- PP 218 - Classified
- PP 219
Huntzinger, R. LaVar, "Market Analysis with Rational Expectations: Theory and Estimation," 60 pp., Apr 78, AD A054 422
- PP 220
Maurer, Donald E., "Diagonalization by Group Matrices," 26 pp., Apr 78, AD A054 443
- PP 221
Weinland, Robert G., "Superpower Naval Diplomacy in the October 1973 Arab-Israeli War," 76 pp., Jun 1978 (Published in Superpower in the Mediterranean: Political Utility and Military Constraints, The Washington Papers No. 61, Beverly Hills and London: Sage Publications, 1979) AD A055 564
- PP 222
Mizrahi, Maurice M., "Correspondence Rules and Path Integrals," 30 pp., Jun 1978 (Invited paper presented at the CNRS meeting on "Mathematical Problems in Feynman's Path Integrals," Marseille, France, May 22-26, 1978) (Published in Springer Verlag Lecture Notes in Physics, 106, (1979), 234-253) AD A055 536
- PP 223
Mangel, Marc, "Stochastic Mechanics of Molecule Molecule Reactions," 21 pp., Jun 1978, AD A056 227
- PP 224
Menger, Marc, "Aggregation, Bifurcation, and Extinction in Exploited Animal Populations," 48 pp., Mar 1978, AD A058 536
*Portions of this work were started at the Institute of Applied Mathematics and Statistics, University of British Columbia, Vancouver, B.C., Canada
- PP 225
Mangel, Marc, "Oscillations, Fluctuations, and the Hopf Bifurcation," 43 pp., Jun 1978, AD A058 537
*Portions of this work were completed at the Institute of Applied Mathematics and Statistics, University of British Columbia, Vancouver, Canada.
- PP 226
Relston, J. M. and J. W. Mann, "Temperature and Current Dependence of Degradation in Red-Emitting GaP LEDs," 34 pp., Jun 1978 (Published in Journal of Applied Physics, 50, 3630, May 1979) AD A058 538
*Bell Telephone Laboratories, Inc.
- PP 227
Mangel, Marc, "Uniform Treatment of Fluctuations at Critical Points," 50 pp., May 1978, AD A058 539
- PP 228
Mangel, Marc, "Relaxation at Critical Points: Deterministic and Stochastic Theory," 34 pp., Jun 1978, AD A058 540
- PP 229
Mangel, Marc, "Diffusion Theory of Reaction Rates, I: Formulation and Einstein-Smoluchowski Approximation," 50 pp., Jan 1978, AD A058 541
- PP 230
Mangel, Marc, "Diffusion Theory of Reaction Rates, II Ornstein-Uhlenbeck Approximation," 34 pp., Feb 1978, AD A058 542
- PP 231
Wilson, Desmond P., Jr., "Naval Projection Forces: The Case for a Responsive MAF," Aug 1978, AD A054 543
- PP 232
Jacobson, Louis, "Can Policy Changes Be Made Acceptable to Labor?" Aug 1978 (Submitted for publication in Industrial and Labor Relations Review), AD A061 528

*CMA Professional Papers with an AD number may be obtained from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22151. Other papers are available from the Management Information Office, Center for Naval Analysis, 2000 North Beauregard Street, Alexandria, Virginia 22311. An index of Selected Publications is also available on request. The index includes a Listing of Professional Papers with abstracts; issued from 1969 to June 1981.

- PP 233
Jacobson, Louis, "An Alternative Explanation of the Cyclical Pattern of Quits," 23 pp., Sep 1978
- PP 234 - Revised
Jondrow, James and Levy, Robert A., "Does Federal Expenditure Displace State and Local Expenditure: The Case of Construction Grants," 25 pp., Oct 1979, AD A061 529
- PP 235
Mizrahi, Maurice M., "The Semiclassical Expansion of the Anharmonic-Oscillator Propagator," 41 pp., Oct 1978 (Published in Journal of Mathematical Physics 20 (1979) pp. 844-855), AD A061 538
- PP 237
Maurer, Donald, "A Matrix Criterion for Normal Integral Bases," 10 pp., Jan 1979 (Published in the Illinois Journal of Mathematics, Vol. 22 (1978), pp. 672-681)
- PP 238
Utgoff, Kathleen Classen, "Unemployment Insurance and The Employment Rate," 20 pp., Oct 1978 (Presented at the Conference on Economic Indicators and Performance: The Current Dilemma Facing Government and Business Leaders, presented by Indiana University Graduate School of Business), AD A061 527
- PP 239
Trost, R. P. and Warner, J. T., "The Effects of Military Occupational Training on Civilian Earnings: An Income Selectivity Approach," 38 pp., Nov 1979k, AD A077 831
- PP 240
Powers, Bruce, "Goals of the Center for Naval Analyses," 13 pp., Dec 1978, AD A063 759
- PP 241
Mangel, Marc, "Fluctuations at Chemical Instabilities," 24 pp., Dec 1978 (Published in Journal of Chemical Physics, Vol. 69, No. 8, Oct 15, 1978), AD A063 787
- PP 242
Slapson, William R., "The Analysis of Dynamically Interactive Systems (Air Combat by the Numbers)," 160 pp., Dec 1978, AD A063 760
- PP 243
Slapson, William R., "A Probabilistic Formulation of Murphy Dynamics as Applied to the Analysis of Operational Research Problems," 18 pp., Dec 1978, AD A063 761
- PP 244
Sherman, Allan and Morawitz, Stanley A., "Maintenance Costs of Complex Equipment," 20 pp., Dec 1978 (Published By The American Society of Naval Engineers, Naval Engineers Journal, Vol. 91, No. 6, Dec 1979) AD A071 473
- PP 245
Slapson, William R., "The Accelerometer Methods of Obtaining Aircraft Performance from Flight Test Data (Dynamic Performance Testing)," 403 pp., Jun 1979, AD A075 226
- PP 246
Brechling, Frank, "Layoffs and Unemployment Insurance," 35 pp., Feb 1979 (Presented at the Nber Conference on "Low Income Labor Markets," Chicago, Jun 1978), AD A096 629
- PP 248
Thomas, James A., Jr., "The Transport Properties of Dilute Gases in Applied Fields," 183 pp., Mar 1979, AD A096 464
- PP 249
Glasser, Kenneth S., "A Secretary Problem with a Random Number of Choices," 23 pp., Mar 1979
- PP 250
Mangel, Marc, "Modeling Fluctuations in Macroscopic Systems," 26 pp., Jun 1979
- PP 251
Trost, Robert P., "The Estimation and Interpretation of Several Selectivity Models," 37 pp., Jun 1979, AD A075 941
- PP 252
Nunn, Walter R., "Position Finding with Prior Knowledge of Covariance Parameters," 5 pp., Jun 1979 (Published in IEEE Transactions on Aerospace & Electronic Systems, Vol. AES-15, No. 3, Mar 1979)
- PP 253
Glasser, Kenneth S., "The d-Choice Secretary Problem," 32 pp., Jun 1979, AD A075 225
- PP 254
Mangel, Marc and Quenbeck, David B., "Integration of a Bivariate Normal Over an Offset Circle," 14 pp., Jun 1979, AD A096 471
- PP 255 - Classified, AD B051 441L
- PP 256
Maurer, Donald E., "Using Personnel Distribution Models," 27 pp., Feb 1980, AD A082 218
- PP 257
Thaler, R., "Discounting and Fiscal Constraints: Why Discounting is Always Right," 10 pp., Aug 1979, AD A075 224
- PP 258
Mangel, Marc S. and Thomas, James A., Jr., "Analytical Methods in Search Theory," 86 pp., Nov 1979, AD A077 832
- PP 259
Glass, David V.; Hsu, Ih-Ching; Nunn, Walter R., and Perlin, David A., "A Class of Commutative Markov Matrices," 17 pp., Nov 1979, AD A077 833
- PP 260
Mangel, Marc S. and Cope, Davis K., "Detection Rate and Sweep Width in Visual Search," 14 pp., Nov 1979, AD A077 834
- PP 261
Vile, Carlos L.; Zvijec, David J. and Ross, John, "Franck-Condon Theory of Chemical Dynamics. VI. Angular Distributions of Reaction Products," 14 pp., Nov 1979 (Reprinted from Journal Chemical Phys. 70(12), 15 Jun 1979), AD A076 287
- PP 262
Petersen, Charles C., "Third World Military Elites in Soviet Perspective," 50 pp., Nov 1979, AD A077 835
- PP 263
Robinson, Kathy L., "Using Commercial Tankers and Container-ships for Navy Underway Replenishment," 25 pp., Nov 1979, AD A077 836

PP 264

Weinland, Robert G., "The U.S. Navy in the Pacific: Past, Present, and Glimpses of the Future," 31 pp., Nov 1979 (Delivered at the International Symposium on the Sea, sponsored by the International Institute for Strategic Studies, The Brookings Institution and the Yomiuri Shimbun, Tokyo, 16-20 Oct 1978) AD A066 837

PP 265

Weinland, Robert G., "War and Peace in the North: Some Political Implications of the Changing Military Situation in Northern Europe," 18 pp., Nov 1979 (Prepared for presentation to the Conference of the Nordic Balance in Perspective: The Changing Military and Political Situation, Center for Strategic and International Studies, Georgetown University, Jun 15-16, 1978) AD A077 838

PP 266

Utgoff, Kathy Clesser, and Brechling, Frank, "Taxes and Inflation," 25 pp., Nov 1979, AD A081 194

PP 267

Trost, Robert P., and Vogel, Robert C., "The Response of State Government Receipts to Economic Fluctuations and the Allocation of Counter-Cyclical Revenue Sharing Grants," 12 pp., Dec 1979 (Reprinted from the Review of Economics and Statistics, Vol. LXI, No. 3, August 1979)

PP 268

Thomason, James S., "Seaport Dependence and Inter-State Cooperation: The Case of Sub-Saharan Africa," 141 pp., Jan 1980, AD A081 193

PP 269

Weiss, Kenneth G., "The Soviet Involvement in the Ogaden War," 42 pp., Jan 1980 (Presented at the Southern Conference on Slavic Studies in October, 1979), AD A082 219

PP 270

Ramnek, Richard, "Soviet Policy in the Horn of Africa: The Decision to Intervene," 52 pp., Jan 1980 (To be published in "The Soviet Union in the Third World: Success or Failure," ed. by Robert H. Donaldson, Westview Press, Boulder, Co., Summer 1980), AD A081 195

PP 271

McConnell, James, "Soviet and American Strategic Doctrines: One More Time," 43 pp., Jan 1980, AD A081 192

PP 272

Weiss, Kenneth G., "The Azores in Diplomacy and Strategy, 1940-1945," 46 pp., Mar 1980, AD A085 094

PP 273

Nakada, Michael K., "Labor Supply of Wives with Husbands Employed Either Full Time or Part Time," 39 pp., Mar 1980, AD A082 220

PP 274

Nunn, Walter R., "A Result in the Theory of Spiral Search," 9 pp., Mar 1980

PP 275

Goldberg, Lawrence, "Recruiters Advertising and Navy Enlistments," 34 pp., Mar 1980, AD A082 221

PP 276

Goldberg, Lawrence, "Delaying an Overhaul and Ship's Equipment," 40 pp., May 1980, AD A085 095

PP 277

Mengel, Marc, "Small Fluctuations in Systems with Multiple Limit Cycles," 19 pp., Mar 1980 (Published in SIAM J. Appl. Math., Vol. 38, No. 1, Feb 1980) AD A086 229

PP 278

Mizrahi, Maurice, "A Targeting Problem: Exact vs. Expected-Value Approaches," 23 pp., Apr 1980, AD A085 096

PP 279

Walt, Stephen M., "Causal Inferences and the Use of Force: A Critique of Force Without War," 50 pp., May 1980, AD A085 097

PP 280

Goldberg, Lawrence, "Estimation of the Effects of A Ship's Steaming on the Failure Rate of Its Equipment: An Application of Econometric Analysis," 25 pp., Apr 1980, AD A085 098

PP 281

Mizrahi, Maurice M., "Comment on 'Discretization Problems of Functional Integrals in Phase Space'," 2 pp., May 1980, published in "Physical Review D", Vol. 22 (1980), AD A094 994

PP 283

Dimmukes, Bradford, "Expected Demand for the U.S. Navy to Serve as An Instrument of U.S. Foreign Policy: Thinking About Political and Military Environmental Factors," 30 pp., Apr 1980, AD A085 099

PP 284

J. Kellison, W. Nunn, and U. Sumita,** "The Laguerre Transform," 119 pp., May 1980, AD A085 100
*The Graduate School of Management, University of Rochester and the Center for Naval Analyses
**The Graduate School of Management, University of Rochester

PP 285

Ramnek, Richard B., "Superpower Security Interests in the Indian Ocean Area," 26 pp., Jun 1980, AD A087 113

PP 286

Mizrahi, Maurice M., "On the WKB Approximation to the Propagator for Arbitrary Hamiltonians," 25 pp., Aug 1980 (Published in Journal of Math. Phys., 22(1) Jan 1981), AD A091 307

PP 287

Cope, Davis, "Limit Cycle Solutions of Reaction-Diffusion Equations," 35 pp., Jun 1980, AD A087 114

PP 288

Golman, Walter, "Don't Let Your Slides Flip You: A Painless Guide to Visuals That Really Aid," 28 pp., Oct 1980, AD A092 732

PP 289

Robinson, Jack, "Adequate Classification Guidance - A Solution and a Problem," 7 pp., Aug 1980, AD A091 212

PP 290

Watson, Gregory H., "Evaluation of Computer Software in an Operational Environment," 17 pp., Aug 1980, AD A091 213

PP 291

Maddala, G. S.* and Trost, R. P., "Some Extensions of the Marlowe Press Model," 17 pp., Oct 1980, AD A091 946
*University of Florida

- PP 292
Thomas, James A., Jr., "The Transport Properties of Binary Gas Mixtures in Applied Magnetic Fields," 10 pp., Sept 1980 (Published in Journal of Chemical Physics 72(10), 15 May 1980)
- PP 293
Thomas, James A., Jr., "Evaluation of Kinetic Theory Collision Integrals Using the Generalized Phase Shift Approach," 12 pp., Sept 1980 (Printed in Journal of Chemical Physics 72(10), 15 May 1980)
- PP 294
Roberts, Stephen S., "French Naval Policy Outside of Europe," 30 pp., Sept 1980 (Presented at the Conference of the Section on Military Studies, International Studies Association Kluwer Island, S.C.), AD A091 306
- PP 295
Roberts, Stephen S., "An Indicator of Informal Empire: Patterns of U.S. Navy Cruising on Overseas Stations, 1859-1897," 40 pp., Sept 1980 (Presented at Fourth Naval History Symposium, US Naval Academy, 26 October 1979, AD A091 316)
- PP 296
Dismales, Bradford and Petersen, Charles C., "Maritime Factors Affecting Iberian Security," (Factores Maritimos Que Afectan La Seguridad Iberica) 14 pp., Oct 1980, AD A092 733
- PP 297 - Classified
- PP 298
Mizrahi, Maurice M., "A Markov Approach to Large Missile Attacks," 31 pp., Jan 1981, AD A096 159
- PP 299
Jondrow, James M. and Levy, Robert A., "Wage Leadership in Construction, 19 pp., Jan 1981, AD A094 797
- PP 300
Jondrow, James and Schmidt, Peter, "On the Estimation of Technical Inefficiency in the Stochastic Frontier Production Function Model," 11 pp., Jan 1981, AD A096 159
*Michigan State University
- PP 301
Jondrow, James M.; Levy, Robert A. and Hughes, Claire, "Technical Change and Employment in Steel, Autos, Aluminum, and Iron Ore, 17 pp., Mar 1981, AD A099 394
- PP 302
Jondrow, James M. and Levy, Robert A., "The Effect of Imports on Employment Under Rational Expectations," 19 pp., Apr 1981, AD A099 392
- PP 303
Thomason, James, "The Rarest Commodity in the Coming Resource Wars," 3 pp., Aug 1981 (Published in the Washington Star, April 13, 1981)
- PP 304
Duffy, Michael K.; Greenwood, Michael J. and McDowell, John M., "A Cross-Sectional Model of Annual Interregional Migration and Employment Growth: Intertemporal Evidence of Structural Change, 1958-1975," 31 pp., Apr 1981, AD A093 393
*University of Colorado
**Arizona State University
- PP 305
Nunn, Laura H., "An Introduction to the Literature of Search Theory," 32 pp., Jun 1981
- PP 306
Anger, Thomas E., "What Good Are Warfare Models?" 7 pp., May 1981
- PP 307
Thomason, James, "Dependence, Risk, and Vulnerability," 43 pp., Jun 1981
- PP 308
Mizrahi, M.M., "Correspondence Rules and Path Integrals," Jul 1981. Published in "Nuovo Cimento B", Vol. 61 (1981)
- PP 309
Weinland, Robert G., "An (The?) Explanation of the Soviet Invasion of Afghanistan," 44 pp., May 1981
- PP 310
Stanford, Janette M. and Tai Te Wu, "A Predictive Method for Determining Possible Three-dimensional Foldings of Immunoglobulin Backbones Around Antibody Combining Sites," 19 pp., Jun 1981 (Published in J. theor. Biol. (1981) 88, 421-439
*Northwestern University, Evanston, IL
- PP 311
Boves, Marianne, Brechling, Frank P. R., and Utgoff, Kathleen P. Classen, "An Evaluation of UI Funds," 13 pp., May 1981 (Published in National Commission on Unemployment Compensation's Unemployment Compensation: Studies and Research, Volume 2, July 1980)
- PP 312
Jondrow, James; Boves, Marianne and Levy, Robert, "The Optimum Speed Limit," 23 pp., May 1981
- PP 313
Roberts, Stephen S., "The U.S. Navy in the 1980s," 36 pp., Jul 1981
- PP 314
Jehn, Christopher; Horowitz, Stanley A. and Lockman, Robert F., "Examining the Draft Debate," 20 pp., Jul 1981
- PP 315
Buck, Ralph V., Capt., "Le Catastrophe by any other name...", 4 pp., Jul 1981
- PP 316
Roberts, Stephen S., "Western European and NATO Navies, 1980," 20 pp., Aug 1981
- PP 317
Roberts, Stephen S., "Superpower Naval Crisis Management in the Mediterranean," 35 pp., Aug 1981
- PP 318
Vego, Milan N., "Yugoslavia and the Soviet Policy of Force in the Mediterranean Since 1961," 187 pp., Aug 1981
- PP 319
Smith, Michael W., "Antiair Warfare Defense of Ships at Sea," 46 pp., Sep 1981 (This talk was delivered at the Naval Warfare System and Technology Conference of the American Institute of Aeronautics and Astronautics in Washington on December 12, 1980; in Boston on January 20, 1981; and in Los Angeles on June 12, 1981.)

- PP 320
Trost, R.P.; Lurie, Philip and Berger, Edward, "A Note on Estimating Continuous Time Decision Models," 15 pp., Sep 1981
- PP 321
Duffy, Michael K. and Ladman, Jerry R., "The Simultaneous Determination of Income and Employment in United States--Mexico Border Region Economies," 34 pp., Sep 1981
*Associate Professor of Economics, Arizona State University, Tempe, AZ.
- PP 322
Warner, John T., "Issues in Navy Manpower Research and Policy: An Economist's Perspective," 66 pp., Dec 1981
- PP 323
Bomse, Frederick M., "Generation of Correlated Log-Normal Sequences for the Simulation of Clutter Echoes," 33 pp., Dec 1981
- PP 324
Horowitz, Stanley A., "Quantifying Seapower Readiness," 6 pp., Dec 1981 (Published in Defense Management Journal, Vol. 18, No. 2)
- PP 327
Hammon, Colin, Capt., USN and Graham, David R., Dr., "Estimation and Analysis of Navy Shipbuilding Program Disruption Costs," 12 pp., Mar 1980
- PP 328
Weinland, Robert G., "Northern Waters: Their Strategic Significance," 27 pp., Dec 1980
- PP 330
Lockman, Robert F., "Alternative Approaches to Attrition Management," 30 pp., Jan 1982
- PP 333
Lee, Lung-Fel and Trost, Robert P., "Estimation of Some Limited Dependent Variable Models with Application to Housing Demand," 26 pp., Jan 1982. Published in Journal of Econometrics 8 (1978) 357-382.
- PP 334
Kenny, Lawrence W., Lee, Lung-Fel, Maddala, G.S., and Trost R.P., "Returns to College Education: An Investigation of Self-Selection Bias Based on the Project Talent Data," 15 pp., Jan 1982. Published in International Economic Review, Vol. 20, No. 3, October 1979.
- PP 335
Lee, Lung-Fel, G.S. Maddala, and R.P. Trost, "Asymptotic Covariance Matrices of Two-Stage Probit and Two-Stage Tobit Methods for Simultaneous Equations Models with Selectivity," 13 pp., Jan 1982. Published in Econometrics, Vol. 48, No. 2 (March, 1980).
- PP 336
O'Neill, Thomas, "Mobility Fuels for the Navy," 13 pp., Jan 1982. Accepted for publication in Naval Institute Proceedings.
- PP 337
Warner, John T. and Goldberg, Matthew S., "The Influence of Non-Pecuniary Factors on Labor Supply," 23 pp., Dec 1981
- PP 339
Wilson, Desmond P., "The Persian Gulf and the National Interest," 11 pp., Feb 1982
- PP 340
Lurie, Philip, Trost, R.P., and Berger, Edward, "A Method for Analyzing Multiple Spell Duration Data," 34 pp., Feb 1982
- PP 341
Trost, Robert P. and Vogel, Robert C., "Prediction with Pooled Cross-Section and Time-Series Data: Two Case Studies," 6 pp., Feb 1982
- PP 342
Lee, Lung-Fel, Maddala, G.S., and Trost, R.P., "Testing for Structural Change by D-Methods in Switching Simultaneous Equations Models," 5 pp., Feb 1982
- PP 343
Goldberg, Matthew S., "Projecting the Navy Enlisted Force Level," 9 pp., Feb 1982

MED
-8